

Three Mile Island, Unit 1 Summary of Tube-to-Tube Wear

RIC 2013
Steam Generator Operating
Experience

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Purpose

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- ✓ Provide information on tube-to-tube (T-T) wear in the TMI-1 Once Through Steam Generators
 - T1R19 Inspection results
 - How the indications were identified
 - How the indications were characterized
 - Lessons learned
 - Future planned actions

Background

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- ✓ TMI-1 installed AREVA, Enhanced Once Through Steam Generators (EOTSGs) during T1R18
 - Operated January 2010 – October 2011
- ✓ General Design Features
 - 15,597 tubes per EOTSG
 - Alloy 690, 0.625" x 0.0368" Wall Thickness
 - Full depth hydraulic expansions in tubesheets
 - 15 stainless steel tube support plates (TSP)
 - Trefoil broached holes, 1.18" thick
 - Numbered 01S (bottom) – 15S (top)
 - Spacing between TSPs varies from 35" - 46.4"
 - Nominal gap between tubes is 0.25"

T1R19 Inspection Overview

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- ✓ 100% full length inspection of each tube
- ✓ Tube damage mechanisms found in each EOTSG
 - Tube-to-tube support plate wear (T-TSP)
 - Damage mechanism was expected and included in pre-outage Degradation Assessment
 - Tube-to-tube wear (T-T)
 - Damage mechanism was not expected based on operational history of similar steam generators



T1R19 T-T Wear Identification

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- ✓ Initially reported as Absolute Drift Indications (ADI) using bobbin coil probe
 - Industry standard is to use I-Codes to identify (possible) flaw signals where no qualified sizing technique exists and supplemental testing is required.
 - Exelon guidelines require analysts to report all indications of suspected tube wall degradation.



T1R19 T-T Wear Characterization

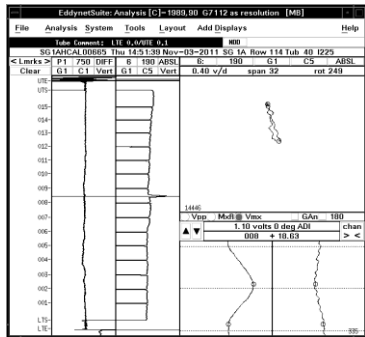
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- ✓ Pattern of absolute drift indications (ADIs) was evaluated to determine potential sources of the indications:
- ✓ Majority of the indications are characterized as:
 - In mid-span
 - In the 9th span
 - In a radial pattern 30" – 45"
 - In adjacent tubes (two or three)



Example TMI-1 T-T Wear Bobbin Data

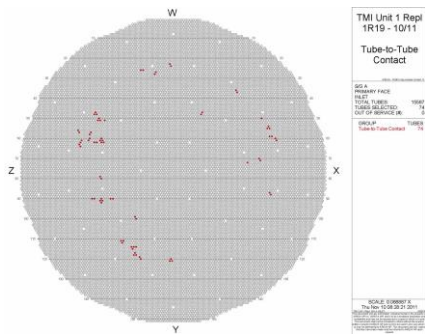
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EOTSG A, T-T Wear Map

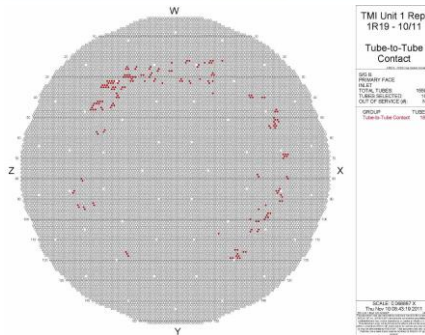
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EOTSG B, T-T Wear Map

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T1R19 T-T Wear Supplemental Examinations

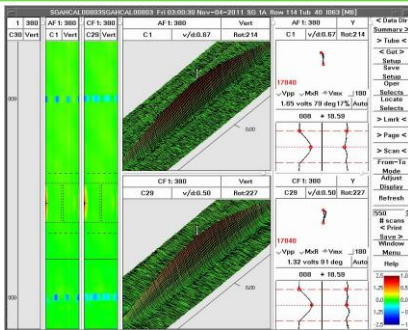
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- ✓ Performed X-Probe and +Point on ADI signals
 - Verified indications in adjacent tubes face each other
 - Symmetrically tapered to maximum depth in center
 - In adjacent tubes the indications are at same elevation and are same length/depth
 - Length and depth have a correlation that is consistent with wear
 - Good correlation of phase angles and voltages between channels



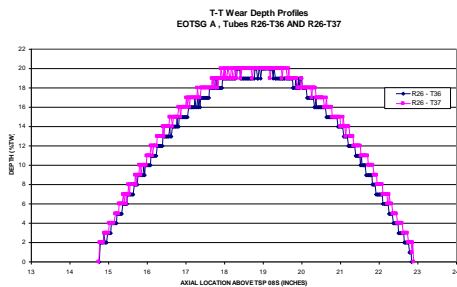
Example TMI-1 T-T Wear X-Probe Data

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Example Depth Profiles in Paired Tubes

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Industry Notifications

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- ✓ Eddy Current Data Analysts, Exelon Engineering, and AREVA Engineering reached consensus that tube-to-tube wear is present
 - Notified Steam Generator Management Program (SGMP) per the requirements of Nuclear Energy Institute (NEI) 97-06
 - Notified NRC



T1R19 T-T Wear Summary

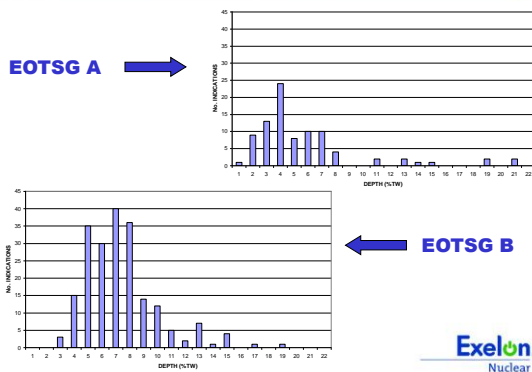
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- ✓ A total of 257 tubes were identified with T-T wear
 - EOTSG A: 89 indications in 74 tubes
 - EOTSG B: 206 indications in 183 tubes
- ✓ Wear depths range from 1% to 21% through wall (TW)
- ✓ Wear axial lengths range from 2" to 8"
- ✓ No proximity or tube contact detected
 - Tubes are in tension at cold conditions and in compression at hot conditions
- ✓ All tubes met condition monitoring limits and in-situ pressure testing was not required



T-T Wear Depth Distribution

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TMI-1 Tube-to-Tube Wear Conclusions

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- ✓ T-T wear was identified during the first inservice inspection of the TMI-1 EOTSGs
- ✓ All T-T wear indications meet Condition Monitoring and Operational Assessment performance criteria
 - Structural limit allows > 50% through wall flaws
- ✓ T-T wear does not impact inspection interval length for Cycle 19



Lessons Learned

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- ✓ All indications from both absolute and differential channels must be investigated and fully characterized to determine if they represent degradation
- ✓ Data analysts must report all potential degradation
- ✓ Previously unreported damage mechanisms may be present regardless of industry experience



Planned Future Actions

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- ✓ Perform 100% eddy current examinations during T1R20 (Fall 2013)
- ✓ Support AREVA root cause analysis
- ✓ Implement appropriate actions based on the results of the root cause